

<b>Ionising Radiations Regulations 2017 (IRR17) Regulation 8 – Radiation Risk Assessment Guidance in Relation to the Civil Transport of Radioactive Material by Road, Rail and Inland Waterway</b>			
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## Table of Contents

1. Introduction .....	2
2. Guidance .....	4
References .....	14

# 1. Introduction

## 1.1. Purpose

1. The requirements of the Ionising Radiations Regulations 2017 (IRR17) [1] and the Carriage of Dangerous Goods Regulations 2009 (CDG09) [2] in relation to the civil transport of radioactive material by road, rail and inland waterway are enforced by the Office for Nuclear Regulation (ONR).
2. CDG09 makes an explicit link between IRR17 radiation risk assessments (RRAs) and CDG09 emergency planning requirements. Those involved in transporting class 7 (radioactive material) goods (consignors or carriers) must carry out a RRA and use the findings to inform the type of accident and emergency arrangements required to be produced.
3. The following guidance sets out ONR's expectations in relation to what constitutes a 'suitable and sufficient' RRA in relation to the transport of radioactive material as required by Regulation 8 of IRR17. In developing this guidance ONR has liaised with the Health and Safety Executive (HSE) in line with the Memorandum of Understanding [3] relating to effective regulation of the transport of radioactive material.
4. Reference is made to IRR17, the Approved Code of Practice (ACoP) and supporting guidance contained within 'Work with ionising radiation' (L121, 2<sup>nd</sup> edition) [1]. Paragraphs 62 to 84 provide guidance in relation to RRAs, with paragraphs 70 and 71 clearly distinguished as ACoP (code with a special legal status that gives practical advice on how to comply with the law).

## 1.2. Scope and Applicability

5. Transport as defined in IRR17 [1] means carriage of a radioactive substance by road, rail, inland waterway, sea or air. The IRR17 definition of transport also states that a radioactive substance is deemed to be transported from the time it is loaded onto a conveyance until it is unloaded from the conveyance. Under the Health and Safety (Enforcing Authority) Regulations 1998 [4] ONR, as the enforcing authority for IRR17, has a wider enforcement responsibility and will therefore consider IRR17 requirements as they apply to preparation of a package, loading, in-transit storage and unloading at its destination as well as carriage. As such employers should ensure they have prepared 'suitable and sufficient' RRAs that reflect this range of practices, both in relation to normal transport operations and transport events (accidents, breakdowns, theft etc). Significant assessment findings must be recorded where an employer has five or more employees.

## 1.3. Definitions

**Table 1: Table of Definitions**

Term/Acronym	Description
ACoP	Approved Code of Practice
ADR	The Agreement concerning the International Carriage of Dangerous Goods by Road
ALARP	As Low As Reasonably Practicable
ONR	Office for Nuclear Regulation
CDG09	Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2009 (as amended)
DU	Depleted Uranium
HSE	Health and Safety Executive
IAEA	International Atomic Energy Agency
IRR17	Ionising Radiations Regulations 2017
PPE	Personal Protective Equipment
RID	The Regulation concerning the International Carriage of Dangerous Goods by Rail
RPA	Radiation Protection Adviser
RRA	Radiation Risk Assessment

## 2. Guidance

### 2.1. Who needs a RRA and when?

7. There can be many duty holders involved in a transport chain and their level of involvement can vary. Some coordinate logistics from afar, and others are much more directly involved. Any employer with any direct involvement with the physical transport of radioactive material, including in-transit storage, as consignor, carrier, packer, loader, filler, unloader or consignee must have developed proportionate RRA(s) reflecting their involvement in this work with ionising radiation before it commences.
8. Where transport involves multiple dutyholders, for example a consignor with one or more carriers, IRR17 Regulation 16 specifically requires dutyholders to co-operate by the exchange of information. Dutyholders should pro-actively share relevant aspects, potentially all, of their RRAs with other dutyholders.

### 2.2. What constitutes a 'suitable and sufficient' RRA?

9. The IRR17 ACoP provides detailed information in paragraph 70 (a) to (m) in relation to matters to be considered, where relevant, by the employer where a RRA is required. The RRA will help the employer to decide on a range of appropriate next steps, outlined in paragraph 71 (a) to (p).
10. To be "suitable and sufficient", ONR expects all ACoP paragraph 70 matters to have been considered, where they are relevant, and the employer to have made suitably informed decisions in relation to ACoP paragraph 71 matters, where appropriate.
11. Where a facility carries out packing and loading as the end function of a main activity (for example radiopharmaceutical production or sealed source radiography) then there may be aspects of the activity that are covered by a facility RRA as well as a transport RRA. In cases where a separate transport RRA is produced it can reference out to the facility RRA where appropriate, but the facility RRA should clearly identify which aspects of work are considered transport activities. Where one RRA is produced to cover both facility and transport activities it should clearly identify which aspects of the work are considered transport activities.
12. Table 2 lists the ACoP paragraph 70 requirements and describes ONR's expectations in relation to the transport of radioactive material.

**Table 2: IRR17 ACoP paragraph 70 requirements in relation to the transport of radioactive material**

Para 70	ACOP Requirements	ONR's Regulatory Expectations
(a)	<p>The nature of sources of ionising radiation to be used, or likely to be present, including accumulation of radon in the working environment.</p>	<p>Include a list of radionuclides in a package, in a consignment or on a conveyance, a description of their physical form (liquid/solid/gas/<i>special form</i><sup>1</sup>), typical and maximum activity of source(s) and type(s) of radiation emitted (alpha/beta/gamma/neutron etc.)</p> <p>Some employers such as busy Class 7 (radioactive material) dangerous goods carriers may choose to have a bounding case or cases (the most pessimistic package/consignment that could be transported), rather than describing each individual source, which include typical maximum activities of the bounding case radioisotope(s). This information should be obtained from the consignor(s).</p> <p>In the main, transport operations are unlikely to take place in or give rise to working environments where significant accumulation of naturally occurring radon gas is likely. However, exposure to radon should be considered (see <a href="#">HSE Radon in the Workplace guidance</a>) in relation to transport work undertaken in buildings located in <a href="#">radon affected areas</a>, or where for instance the nature of the sources is such that radon is produced, and where material is stored in-transit for a period. Where radon has been considered and discounted a statement to this effect should be included.</p>
(b)	<p>Estimated radiation dose rates to which anyone can be exposed.</p>	<p>Estimate whole effective body doses, equivalent doses to hands, extremities, eyes etc. (as appropriate) to employees involved in preparing, handling, storing, loading, carrying and unloading packages containing radioactive material. Take account of the number and types of packages, accessible dose rates (typical and maximum) and time spent working with them.</p> <p>Estimate effective doses to other persons who may be in the vicinity where dose rates exceed normal background levels.</p> <p>Estimated dose rates should be justified through the use of calculations or physical readings, with assumptions</p>

<sup>1</sup> Special Form is defined in IAEA Specific Safety Requirements No. SSR-6 (Rev. 1) Regulations for the Safe Transport of Radioactive Material (2018 Edition): [https://www-pub.iaea.org/MTCD/Publications/PDF/PUB1798\\_web.pdf](https://www-pub.iaea.org/MTCD/Publications/PDF/PUB1798_web.pdf).



Para 70	ACOP Requirements	ONR's Regulatory Expectations
		<p>clearly defined. Where physical readings have been taken these can be used to support calculations but shouldn't be used as final estimates without justification that they bound all cases.</p> <p>Note that factors affecting exposure whilst driving will include: Vehicle size, position of packages in vehicle, number and category of package (I-White, II- Yellow and III-Yellow) journey times, number of available drivers for Class 7 work, and shift pattern. This list is not exhaustive.</p>
(c)	<p>The likelihood of contamination arising and being spread.</p>	<p>The physical form the material takes will have a significant bearing on the likelihood of contamination arising and being spread. Consider the potential for contamination arising from the radioactive contents both in routine and accident conditions. Also consider whether the working environment is such that contamination of a package is reasonably foreseeable i.e. are contamination control procedures robust, could the integrity of the package be compromised? Note that this should also be considered in the case of the transport of <i>special form</i><sup>1</sup> radioactive material, although the risk of contamination is extremely low.</p> <p>Specify the frequency of contamination monitoring of areas/vehicles. More frequently for liquids, less so for <i>special form</i> radioactive material. See also ONR guidance Transporting radioactive material - Guidance on radiation and contamination monitoring requirements, and determining a Transport Index [5].</p>
(d)	<p>The results of any previous personal dosimetry or area monitoring relevant to the proposed work.</p>	<p>Include typical and maximum previous dosimetry results for individuals and area monitoring results, noting that they can be informative and can support dose estimates at (b) above. If no such information is available then record the reason for this.</p>
(e)	<p>Advice from the manufacture or supplier of equipment about its safe use and maintenance.</p>	<p>Describe how advice on the use and maintenance of equipment/packages is obtained from the manufacturer or supplier and incorporated into operating procedures.</p> <p>Examples of why it is important to ensure equipment/packages are used and maintained in accordance with manufacturer/supplier specifications are:</p>



Para 70	ACOP Requirements	ONR's Regulatory Expectations
		<ul style="list-style-type: none"> <li>▪ Packages may have specified activity limits or specified radioactive contents so deviating from these could significantly increase associated risk.</li> <li>▪ Incorrectly assembled or maintained packages could result in greater doses during routine transport and emergency situations.</li> </ul>
(f)	Engineering control measures and design features already in place or planned.	Describe the engineering control measures and design features. These may be integral to the package, or could for example be integral to the vehicle i.e. shielding material installed at the bulkhead, separating the cargo area from the driver's cab thereby reducing driver dose. In-transit storage locations may need particular engineering controls and design features i.e. dedicated, shielded, lockable store. [IRR17 Regulation 30 and supporting guidance is relevant here.]
(g)	Any planned systems of work.	<p>Describe systems of work that are in place to keep whole body, hand, extremity, eye etc doses As Low As Reasonably Practicable (ALARP). This information is particularly useful in helping to ensure that all systems are in place at the right times and aiding future reviews of the RRA (see para 2.14 below).</p> <p>There are a range of potential systems of work associated with transport operations. For example during in-transit storage temporary barriers may be required to restrict access to an area where dose rates are elevated, or there may be a particular vehicle loading regime and particular sizes of vehicles required to keep vehicle crew dose ALARP.</p> <p>Describe the impact in terms of radiation exposure if planned systems of work are inappropriate or not implemented correctly. For example: If a loading regime is not followed and radioactive material is placed in close proximity to the driver/vehicle crew, or if a smaller vehicle than usual is used, or if shielding afforded by other packages in the consignment isn't available, is there a potential impact on doses received by the driver/vehicle crew? If temporary barriers are not used appropriately during in-transit storage, what is the potential impact on doses to employees working or other persons in the vicinity?</p>
(h)	Estimated levels of airborne and surface	Describe, for normal transport operations, how it is ensured that surface contamination levels fall within



Para 70	ACOP Requirements	ONR's Regulatory Expectations
	contamination likely to be encountered.	<p>prescribed limits set out on modal legislation relating to transport i.e. The Agreement concerning the International Carriage of Dangerous Goods by Road (ADR), The Regulation concerning the International Carriage of Dangerous Goods by Rail (RID) etc. [2].</p> <p>Issues to consider include, but are not limited to, is it reasonable to assume a package will be relatively 'clean' considering the working environment it has been in? Does the consignor have robust contamination control procedures?</p> <p>Assuming surface contamination levels fall within prescribed limits set out on modal legislation relating to transport, the risk should be low.</p>
(i)	The effectiveness and suitability of PPE to be provided.	<p>Describe the Personal Protective Equipment (PPE) to be provided and the reasons for its provision.</p> <p>There are limited practical PPE options where radioactive material is being transported, and there are none which impact to any significant extent on external exposure arising during transport where gamma radiation is typically encountered. General items such as gloves and protective eyewear are typically available where unsealed material is being prepared for transport, and during carriage. Although, they are not designed to offer particular protection from exposure to radiation, they are likely to offer some limited protection from contamination in the event of a loss of containment.</p>
(j)	The extent of unrestricted access to working areas where dose rates or contamination levels are likely to be significant.	<p>Summarise the scenarios that could result in unrestricted access to working areas where dose rates or contamination levels are likely to be significant.</p> <p>Knowledge of dose rates from packages, consignments and from the surface of the vehicle can be used to assess the impact on members of the public in the event of a reasonably foreseeable event such as vehicle breakdown/accident on roads where pedestrians/other drivers are in close proximity to the vehicle or where packages are ejected from the vehicle.</p> <p>Knowledge of maximum likely dose rates from temporary or dedicated storage areas can be used to assess the impact on workers and members of the public in the vicinity.</p>



Para 70	ACOP Requirements	ONR's Regulatory Expectations
		Contamination levels are unlikely to be significant in normal operations, however in accident situations they could be very significant.
(k)	Possible accident situations, their likelihood and potential severity.	<p>Identify all reasonably foreseeable accidents. This means accidents that are less than likely, but realistically possible.</p> <p>Assess accident doses for the full range of potential accident scenarios identified and make a clear conclusion whether a radiation emergency is possible<sup>2</sup>. Since transport emergency arrangements obviously include package retrieval and where appropriate decontamination, ONR considers these activities to be part of the emergency until a stable state is achieved. Therefore, accident dose estimation should include doses that could reasonably be expected to be accrued during retrieval and decontamination until the radioactive material is contained in a safe location or able to be onwardly transported in accordance with CDG09.</p> <p>Include a clear statement regarding the emergency arrangements required to be produced<sup>3</sup>.</p> <p>In relation to transport, possible accident situations may include:</p> <ul style="list-style-type: none"> <li>▪ Damage to Class 7 consignments arising from vehicle fire, collision, adverse road conditions.</li> <li>▪ Dropped, crushed or damaged package/s.</li> <li>▪ Theft of package(s) with or without theft of vehicle.</li> </ul>

<sup>2</sup> The definition of a radiation emergency includes serious consequences that might arise from exposure to radioactive material including consequences to human life, health and safety, quality of life, property and the environment. In most cases there are no serious radiological consequences at or below a threshold of an effective radiation dose of 1 mSv to any individual over a period of one year following the radiation emergency.

<sup>3</sup> CDG09 requires duty holders to make an adequate emergency plan for any radiation emergency identified by the duty holder's IRR17 RRA. Where assessments identify that a radiation emergency is possible, an adequate emergency plan in accordance with Regulation 24 and Schedule 2 Part 1 of CDG09 is required. This plan must also meet the requirements of IRR17 Regulation 13 'Contingency plans'. Where assessments identify that a radiation emergency is not possible, there is no requirement for an emergency plan in accordance with Regulation 24 and Schedule 2 Part 1 of CDG09, however the requirements of IRR17 Regulation 13 'Contingency plans' still apply. Where dutyholders are transporting a wide variety of radioactive material they may be required to produce both a CDG09 emergency plan and an IRR17 contingency plan. These can be included in a single document, but it should be made clear which plan relates to which packages. ONR's transport emergency planning guidance <http://www.onr.org.uk/transport/emergency-planning-notification-class-7.pdf> and <http://www.onr.org.uk/transport/five-steps-transport-emergency-planning.pdf> refer.

Para 70	ACOP Requirements	ONR's Regulatory Expectations
		<ul style="list-style-type: none"> <li>▪ Loss of package(s) – including temporary loss of control.</li> </ul> <p>This list is not exhaustive.</p> <p>In order to assess accident doses, calculate approximate dose ranges the consequences of accidents might fall within to substantiate 'severity' and inform the overall risk. ONR expects any use of descriptors such as high/medium/low to be supported by information relating to relevant dose ranges. These could be described as 10's or 100's of microsieverts or millisieverts, for instance. Assessment should include consideration of ingestion and or inhalation as well as direct radiation exposure from all radiation sources, including any depleted uranium (DU) shielding used as an integral part of a package design.</p> <p>The International Atomic Energy Agency (IAEA) assumes that in a "median accident" involving a single Type A package with its maximum allowable contents, a dose of 50 mSv could potentially be received by persons in the close vicinity of the package over a period of 30 minutes. ONR expectations are that a radiation emergency is possible where a radionuclide with an activity greater than 1/50<sup>th</sup> of the A2 value is transported (ADR/RID 2.2.7.2.2 refer). In this instance, if it is not considered that 1 mSv could be exceeded, a robust justification should be included.</p> <p>Different assumptions may be made for consignments of packages that are designed to withstand accident conditions of transport (Type B packages<sup>4</sup>) for those designed only to withstand routine conditions of transport (for example, excepted packages). Where assumptions are made, it is appropriate to document them.</p> <p>The number and type of packages in a consignment will need to be considered and bounding cases may be used to address routine transport activities for those that transport a variety of radionuclides/packages routinely.</p>

<sup>4</sup> ONR has historically received incident reports of Type B packages being transported whilst not correctly filled, manufactured/maintained and assembled. Therefore, these aspects cannot be discounted. In addition, there is an understanding that the test conditions for package approvals do not cover all conceivable accident scenarios (IAEA SSG-26 Para 726.1) and that a level of content loss is allowable in a successful test (IAEA SSR-26 Para 659).



Para 70	ACOP Requirements	ONR's Regulatory Expectations
		<p>Assessments should:</p> <ul style="list-style-type: none"> <li>▪ Apply the hierarchy of control principles (<a href="https://www.hse.gov.uk/construction/lwit/assets/downloads/hierarchy-risk-controls.pdf">https://www.hse.gov.uk/construction/lwit/assets/downloads/hierarchy-risk-controls.pdf</a>) .</li> <li>▪ Include doses that could be accrued by all personnel (including emergency services personnel) in recovering packages or include a robust qualitative demonstration that a dose in excess of 1 mSv to any individual over a period of one year following the radiation accident is or is not possible.</li> <li>▪ Consider the impact on employees/others if the package is not assembled, used or maintained in accordance with the advice from the manufacturer/supplier described in 70 (e).</li> <li>▪ Consider the impact if the engineering control measures and design features described in 70 (f) fail or are not implemented correctly.</li> <li>▪ Take into account the consequences, not only of possible plant and equipment failures, but also of a breakdown in work systems and of unauthorised behaviour at work (IRR17 guidance paragraph 83).</li> <li>▪ Where loss or theft of a package has been assessed a reasonably foreseeable accident, include assumptions of the actions of untrained individuals such as members of the public. This may include where loss or theft occurs that the package will deliberately be opened.</li> <li>▪ Include a clear conclusion as to whether a radiation emergency is or is not possible.</li> </ul> <p>Assessments should not:</p> <ul style="list-style-type: none"> <li>▪ Exclude low frequency potential accidents.</li> <li>▪ Rely solely on the robustness of a package type as justification that a potential accident is not possible.</li> <li>▪ Be based upon personnel remaining a certain distance from packages with reliance on recovery operations taking place under health physics supervision and control.</li> </ul>
(I)	The consequences of possible failures	Consider reasonably foreseeable scenarios and their dose consequences. Some specialist packages require

Para 70	ACOP Requirements	ONR's Regulatory Expectations
	of control measures – such as electrical interlocks, ventilation systems and warning devices – or systems of work	cooling, or may require particular locking devices to secure the load. Given the mobile nature of transport operations, failures of systems of work are generally likely to have an impact. Systems of work can include package preparation loading regimes, contamination control measures in workplaces from which packages are consigned, or they could relate to contamination control of packages themselves. If these fail, what are the potential consequences?
(m)	Steps to prevent identified accidents, or limit their consequences	<p>Include details of mitigating measures in place to prevent identified accidents, or limit consequences. Examples include contamination monitoring of packages and measurement of radiation dose rates around packages, correctly assigning Transport Index, and monitoring around vehicles. Training of drivers, carrying of suitable emergency kit, and use of well-maintained vehicles, all have the potential to prevent or limit the consequences of accidents. This list is not exhaustive.</p> <p>Include any security aspects such as vehicle security, tracking of packages/vehicles, escorts and/or camera systems.</p>

13. Having given due consideration to these and any other relevant issues, employers should be in a position to decide on appropriate next steps on matters detailed in IRR17 ACoP paragraph 71 (a) to (p), namely they must:
- a) Specify and take all actions needed to make sure the radiation exposure of all people is kept ALARP (Reg 9(1)).
  - b) Introduce the steps necessary to achieve control of exposure by the use of engineering controls, design features, safety devices and warning devices, and in addition develop systems of work (Reg 9(2)(a) and (b)).
  - c) Provide any necessary PPE (Reg 9(2)(c)).
  - d) Establish any appropriate dose constraints for planning or design purposes (Reg 9(4)).
  - e) Alter working conditions as necessary for any pregnant or breastfeeding employee (Reg 9(6)).
  - f) Introduce an appropriate dose investigation level as an ALARP tool (Reg 9(8)).



- g) Develop maintenance and testing schedules required for the control measures selected (Reg 11).
  - h) Prepare contingency plans for reasonably foreseeable accidents (Reg 13).
  - i) Determine training needs of classified and non-classified employees (Reg15).
  - j) Designate specific areas as controlled or supervised and to specify local rules (Regs 17 and 18). This should include the designation of the load compartment of the vehicle whilst transporting radioactive material or the need to designate areas as a result of an accident arising during carriage where relevant. It may also include the cab of the vehicle during carriage depending on the dose rate. If a consignor identifies that an area within or around a vehicle would potentially need to be designated then this information should be pro-actively provided to all relevant carrier dutyholders.
  - k) Restrict access and implement other measures required for controlled/supervised areas (Reg 19).
  - l) Determine who, if any, will be classified persons (Reg 21).
  - m) Introduce a suitable programme of dose assessment for certain employees (those that are classified, and those entering controlled areas) (Regs 19 and 22).
  - n) Decide whether there are any sources requiring leak testing (Reg 28).
  - o) Allocate responsibilities to managers and workers (including outside workers) as appropriate for compliance with IRR17.
  - p) Develop a programme of monitoring or auditing of arrangements to check IRR17 requirements are being met.
14. Relevant action should be taken ahead of transport commencing.

### 2.3. Further important information

15. There is a requirement for the employer to consult with a suitable Radiation Protection Adviser (RPA) about the matters to be considered as part of the RRA process [IRR17, Regulation 14 refers as does ACoP para 249 and guidance in para 72] and for appropriate action to be taken in relation to its findings ahead of transport commencing.
16. Not all IRR17 requirements relevant to transporting radioactive material are addressed through the RRA process. For example, compliance with

Regulations 6 (registration of certain practices), 7 (consent to carry out specified practices) and 31 (notification of certain occurrences). This list is not exhaustive.

17. A suitable RPA will be able to provide any further advice in relation to IRR17 compliance.
18. The significant findings of a RRA must be recorded where the duty holder has five or more employees. ONR expects the employer to be conversant with, and explain at any inspection the RRA findings that were significant, so for practical reasons it may help to record this information to demonstrate compliance. [Further guidance is contained in paragraph 77 of L121.]
19. Where an employer develops a RRA for a particular set of transport circumstances i.e. a given number of a certain package type for instance, there needs to be a means of readily identifying when those circumstances are not met so that the required RRA can be developed, and action taken accordingly, ahead of transport.
20. RRAs must be reviewed periodically, and where work changes, and revised as necessary. [Further guidance is contained in paragraph 78 to 81 of L121.] A prompt for the review process may usefully sit within an employer's management arrangements or system.

## References

- [1] *Work with ionising radiation, Ionising Radiations Regulations 2017, Approved Code of Practice and Guidance*, Health and Safety Executive, 2018.
- [2] *The Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2009*, UK Government, 2009.
- [3] *Memorandum of Understanding between ONR and HSE on the effective regulation of the IRR17 in relation to the transport of radioactive material*, ONR, 2021.
- [4] *The Health and Safety (Enforcing Authority) Regulations 1998*, UK Government, 1998.
- [5] *Transporting radioactive material - Guidance on radiation and contamination monitoring requirements, and determining a Transport index*, ONR, 2016.